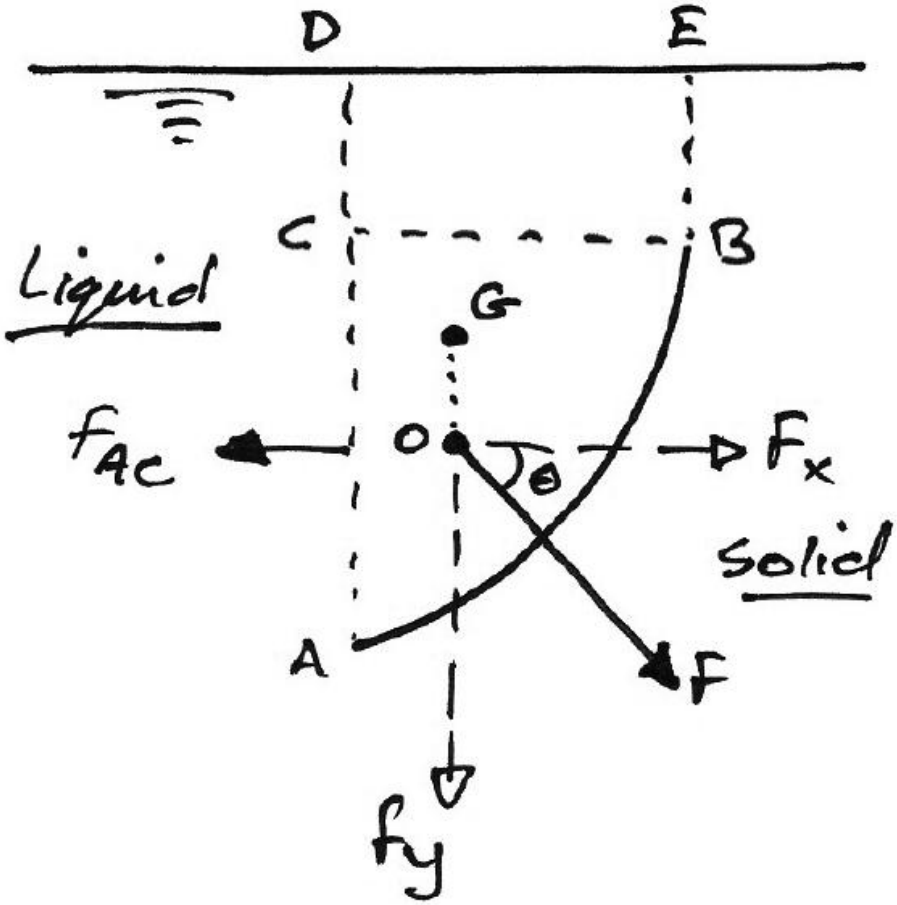
HYDRO STATICS

FLUID ACTION ON SURFACES

Fluid Action on Surfaces

Curved Surfaces

For curved surfaces the fluid pressure on the infinitesimal areas are not parallel and so must be combined vectorially. It is usual to consider the total horizontal and vertical force components of the resultant.



Surface Containing Liquid

Consider the surface AB which contains liquid as shown below:

Fluid Action on Surfaces

Curved Surfaces

Horizontal Component:

Using the imaginary plane ACD we can immediately see that the horizontal component of force on the surface must balance with the horizontal force F_{AC}. Hence:

$$F_x = \text{Force on projection of surface onto a vertical plane}$$

F_x must also act at the same level as F_{AC} and so it acts through the center of pressure of the projected surface.

Fluid Action on Surfaces

Curved Surfaces

Vertical Component:

The vertical component of force on the surface must balance the weight of fluid above the surface. Hence:

$$F_y = \text{Weight of liquid directly above the surface}$$

Also, this component must act through the center of gravity of the area *ABED*, shown as *G* on the diagram.

Fluid Action on Surfaces

Curved Surfaces

Resultant:

The resultant force is thus:

$$F = \sqrt{F_x^2 + F_y^2}$$

This force acts through the point O when the surface is uniform into the page, at an angle of:

$$\theta = \tan^{-1} \frac{F_y}{F_x}$$

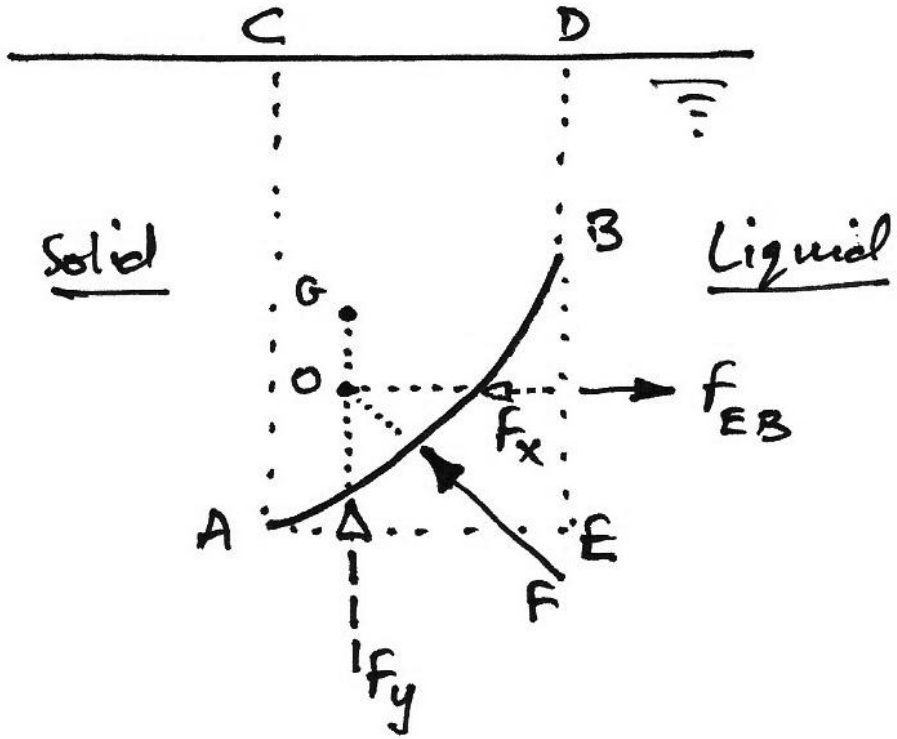
to the horizontal. Depending on whether the surface contains or displaces water the angle is measured clockwise (contains) or anticlockwise (displaces) from the horizontal.

Fluid Action on Surfaces

Curved Surfaces

Surface Displacing Liquid:

Consider the surface AB which displaces the liquid as shown below:



Fluid Action on Surfaces

Curved Surfaces

Horizontal Component:

Similarly to the previous case, the horizontal component of force on the surface must balance with the horizontal force F_{EB}. Hence again:

$$F_x = \begin{matrix}\text{Force on projection of surface} \\ \text{onto a vertical plane}\end{matrix}$$

This force also acts at the same level as F_{EB} as before.

Vertical Component:

In this case we imagine that the area $ABDC$ is filled with the same liquid. In this case F_y would balance the weight of the liquid in area $ABDC$. Hence:

$$F_y = \begin{matrix}\text{Weight of liquid which} \\ \text{would lie above the surface}\end{matrix}$$

Fluid Action on Surfaces

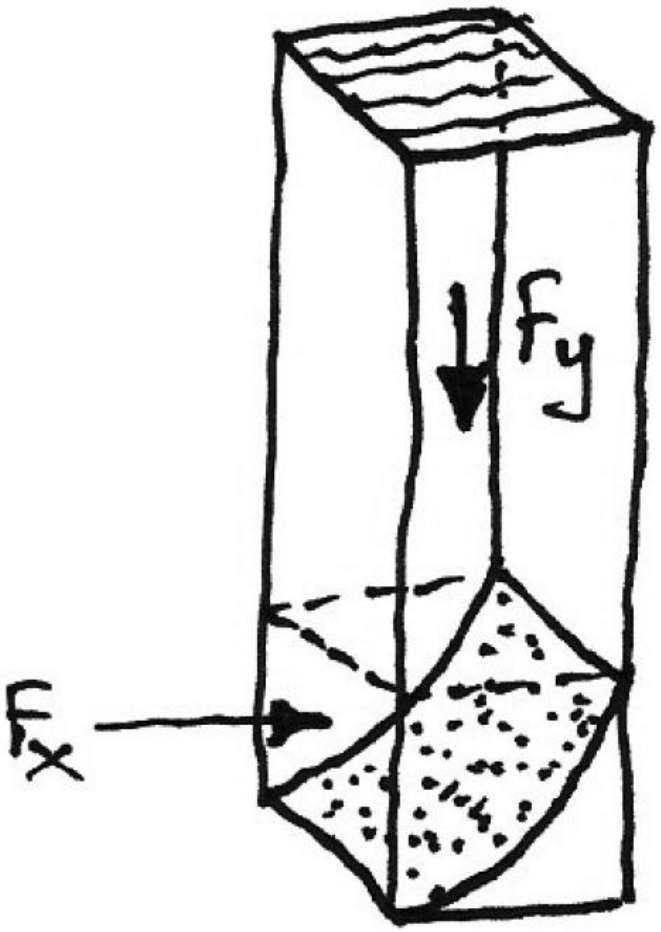
Curved Surfaces

Vertical Component:

This component acts through the center of gravity of the imaginary liquid in area $ABDC$, shown as G on the diagram.

The resultant force is calculated as before.

Both of these situations can be summed up with the following diagram:

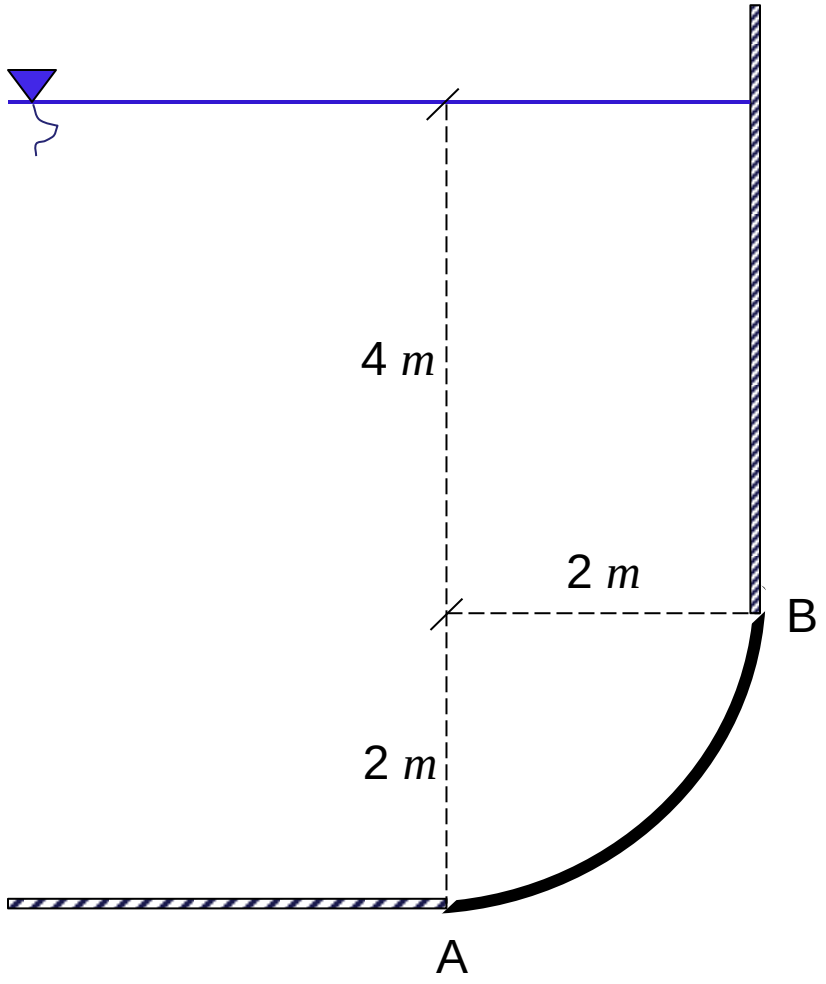


Fluid Action on Surfaces

Problem Set 5

Problem 1

The submerged curve AB is one quarter of a circle of radius 2 m and is located on the lower corner of a tank shown. The length of the tank perpendicular to the sketch is 4 m. Find the magnitude and location of the horizontal and vertical components of the total force acting on AB.

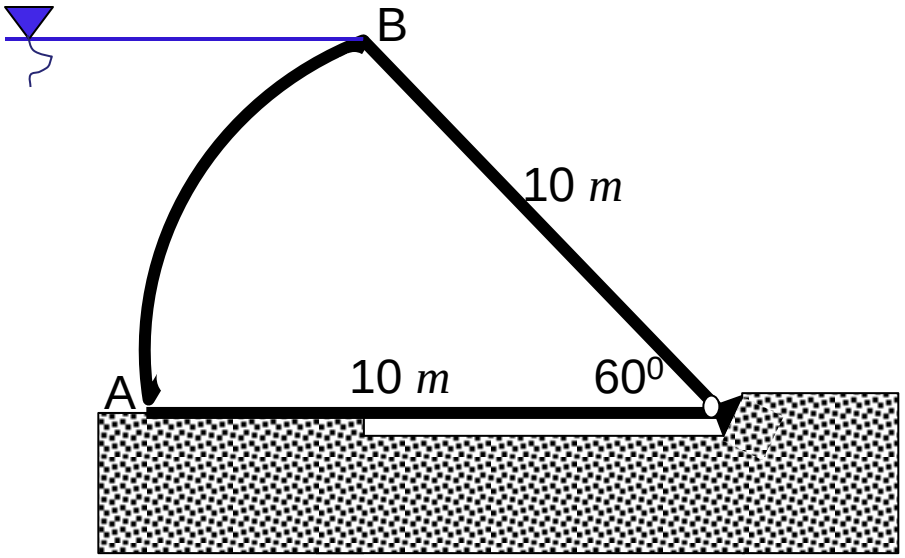


Fluid Action on Surfaces

Problem Set 5

Problem 2

The crest gate shown consists of a cylindrical surface of which AB is the base supported by a structural frame hinged at O. The length of the gate is 10 m. Compute the magnitude and location of the horizontal and vertical components of the total pressure on AB.

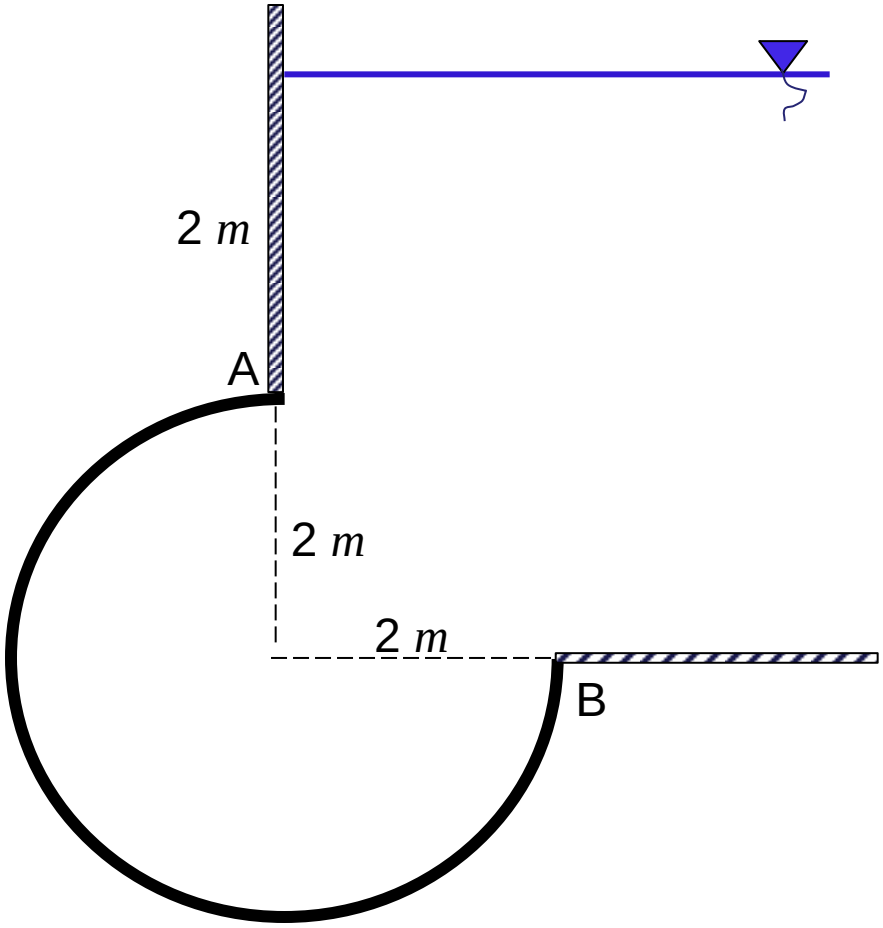


Fluid Action on Surfaces

Problem Set 5

Problem 3

Determine the magnitude of the horizontal and vertical components of the total force per meter length acting on the three-quarter cylinder gate shown.

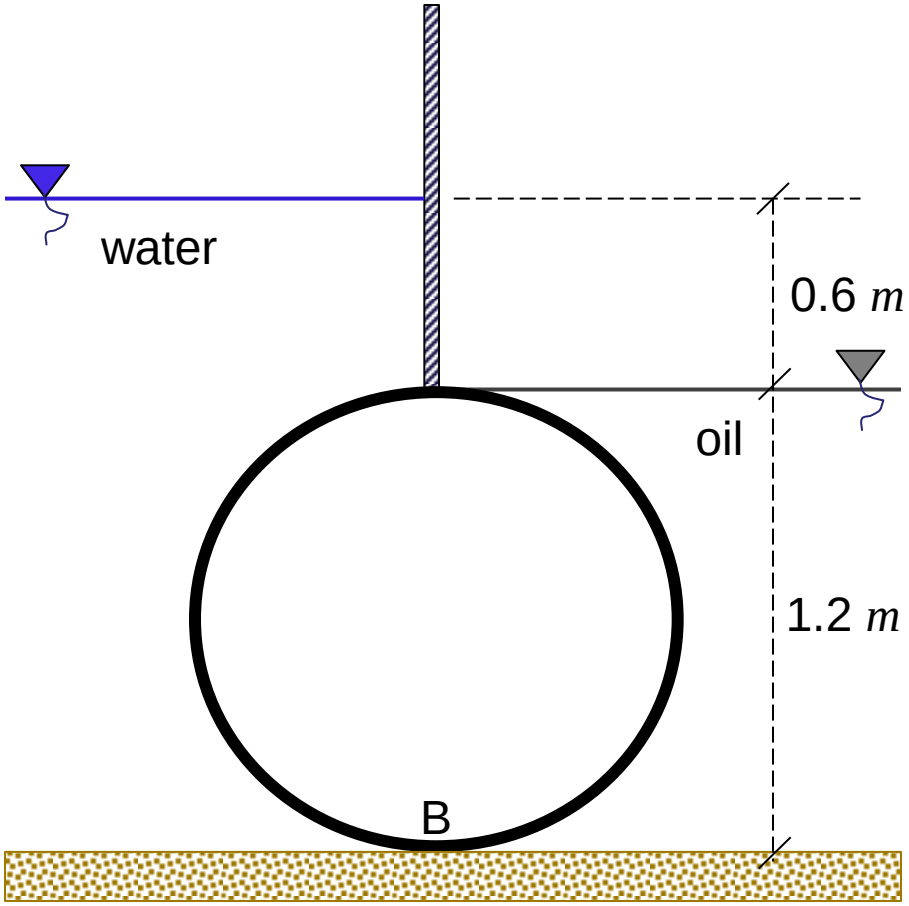


Fluid Action on Surfaces

Problem Set 5

Problem 4

In the figure shown, the 1.20 m diameter cylinder, 1.20 m long is acted upon by the water on the left and oil (s = 0.80) on the right. Determine the components of the reaction at B if the cylinder weighs 19.62 kN.



Fluid Action on Surfaces

Problem Set 5

Problem 5

An inverted conical plug 400 *mm* diameter and 300 *mm* long closes a 200 *mm* diameter circular hole at the bottom of a tank containing 600 *mm* of oil (s = 0.82). Determine the total vertical force acting on the plug.